THE ECONOMIC IMPACT OF TELECOMMUNICATIONS IN SENEGAL (*)

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**Executive Summary**

This study assesses the economic impact of telecommunications to an emerging country. Drawing from the wealth of research literature on economic effects generated on the basis of cross-sectional analyses (e.g. OECD, Latin America, Arab States), it applies econometric tools and techniques to measuring the impact of telecommunications on the Senegalese economy.

The Senegalese telecommunications sector plays a critical role in contributing to the country’s economic development. Telecommunication revenues account for 10.8% (or US $1.4 billion) of the country’s GDP, contributing annually to its growth $104 million, the highest across country sectors, and generating 12.6% of total tax collections. Furthermore, the sector represents 3,000 direct and more than 55,000 indirect jobs.

Beyond the direct economic impact, the indirect contribution through spill-over effects over the rest of the economy was also estimated. This was conducted by constructing structural econometric models specified both for the wireless and broadband sectors. In the case of wireless, the model developed for the period 2004-2011 estimates that mobile telephony contributed an annual 0.55% of GDP, which has grown at an average rate of 4.1%, thus representing 13.6% of all economic growth in Senegal. Furthermore, based on forecasts of subscriber growth (source: Wireless Intelligence) and GDP growth (source: IMF), this impact will accelerate until 2016, reaching 13.8% of all economic growth in the country (an 0.62% contribution to annual GDP growth projected at 4.6%) as the market will eventually saturate.

In the case of broadband, no significant economic effects were found. This is due primarily to the still low levels (0.75%) of broadband penetration. This result is consistent with other studies, indicating that only after 5% penetration, some economic effects can be detected. The dynamic adoption of 3G mobile connections that began in 2010 is forecast to expand to one third of the population by 2016. This situation can transform the market and the economy both in terms of capacity and growth potential.

The policy implications of these results are self-evident. The private telecommunications sector has been able to address the country’s voice telephony needs through wireless price reductions, resulting in a fast adoption process. The forward-looking challenge focuses on applying the lessons from wireless, and leveraging its industry structure to accelerate broadband adoption. Wireless broadband represents the appropriate technological platform to meet this challenge. Its deployment will favour/facilitate the development of domestic and export-oriented economic activity. In parallel, the development of applications in the areas of education, public health, media and entertainment, and government services, will act as incentives to broadband adoption.

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1. Introduction

Since the mid-1970s, social scientists and policy makers had been researching the contribution of information and communication technologies (ICT) to economic development\(^2\). In fact, ever since the first studies conducted by researchers of the World Bank and development agencies, social scientists have been developing tools and techniques to measure the impact of telecommunications on GDP growth, employment creation and productivity, among other metrics.

Until recently, the primary statistical approach to test the economic contribution of ICT has been based on the study of cross-sectional samples of countries. Due to limitations on data availability, the primary emphasis had been on OECD countries (facilitated by the extensive Eurostat data sets) or worldwide analysis (based on ITU statistical indicators). While this approach is continuing to be pursued\(^3\), researchers are starting to focus their assessments on specific country studies. For example, aiming to understand the economic impact of broadband, we have conducted studies for Germany (Katz et al., 2010a), the United States (Katz and Suter, 2009a; Katz et al, 2010), Costa Rica (Katz, 2011c), Chile (Katz, 2010b), Colombia (Katz et al., 2011d) and Peru (Katz, 2011b).

The following study focuses on assessing the economic impact of telecommunications in Senegal. It attempts to analyse the relative impact of wireline, wireless and broadband communications. The measureable economic impact of ICT infrastructure depends heavily on the introduction timing, existing adoption conditions and market maturity. As studies of the lagged impact of ICT have demonstrated (Hardy, 1980; Jorgenson et al., 2006; Karner and Onyiji, 2007), significant economic effects of ICT do not materialize immediately after the introduction of a new technology.

Mobile voice services represent a mature market that has affected the evolution of the Senegalese economy during the last seven years and is now used by the majority of the population. A structural model, relying on four equations that model the market operation was applied in this case. This approach takes into account:

- Endogenous growth from existing capital and labour together with the ICT infrastructural metrics
- Demand for telecommunications services depending on the price and adoption patterns
- Supply and competition of telecommunications taking into account the regulatory and infrastructural investments in ICT
- Revenues and outputs of the telecoms market as a proxy for the ‘health’ and sustainability of the market

\(^2\) See, for example, Madden and Savage (1998), Marsch (1976), Norton (1992), and Schapiro (1976).

\(^3\) See Koutroumpis (2009), Waverman (2009) and Katz (2012).
The Internet/Broadband market has relied on fixed infrastructure and was relatively dormant during the same period. ADSL has still a limited audience while 3G, as a wireless broadband platform, has just been launched. The broadband economic impact is assessed through a structural model similar to the wireless one.

This study begins by providing a brief review of the research literature regarding the impact of telecommunications on the economy (Section 2). In section 3, a view of the primary features of the Senegalese economy is presented and then the key dynamics of the local telecommunications market are explained (Section 4). The review of the literature provides a context for the development of the approach utilized in this study. Having laid out the methodology that was followed, the results of the study are presented and discussed (Section 5). The implications from a public policy standpoint are drawn in Section 6.

2. Impact of Mobile Telephony and Broadband on the economy: a review of the literature

2.1 The impact of Mobile Telephony on the Economy, Jobs and Welfare

Assessing the macroeconomic effects from the deployment and adoption of new technologies is particularly important but their direct effects on everyday life are usually the tangible metrics for their value and use. Mobile phones affect all economies as they provide a platform with communication mobility attributes that either enhance and support innovation driven economies or substitute the lack of traditional fixed-line channels in the developing world.

There is ample support for the effects of mobile communication in regional emerging countries. More informed markets and agents perform more efficiently, are better coordinated and improve consumer welfare. These effects are permanent and not one-time gains as mobile infrastructure becomes a permanent fixture of market economies. An example is the fishery market of Kerala that experienced incredible changes after the introduction of mobile telephony. Prices decreased substantially, waste was eliminated and the fishing sector became a lot more informed and demand-driven (Jensen, 2007). Similarly, the grain market in Niger experienced significant behavioral and consumer/trader welfare improvements. Aker (2008) estimates that, in this case, mean prices fell over 4.5% and well organised markets led to profit increases as well. Another micro-level analysis points to the effects of mobile coverage on market participation of banana farmers in Uganda (Muto, 2008). The existence of mobile coverage and not the possession of mobiles per se, had significant effects on the remote farmers that produce perishable crops as it significantly reduced the cost of crop marketing.

Apart from the basic communication services, mobile networks offer the necessary platform to launch innovative services. In certain cases, these services increase the capacity of existing business channels (retail stores, geolocation, transport services) while in others, they tackle the lack of access to traditional services. A classic
example is the launch of financial services and micropayments through mobile networks in Kenya and Tanzania. In these countries, the rudimentary physical banking network was quickly substituted by cashless transactions with ‘airtime’ trading dramatically reducing the cost of service delivery and transaction burdens. This led to the rapid adoption of basic financial transactions services by millions of ‘unbanked’ population.

Mobile infrastructures have significant effects on the creation of new markets and services, hence reducing unemployment and openness of the economy. The vast substitution taking place through the transition to digital economies suggests a potential transfer of labour force rather than creation. However the net gains from the launch of new services, improvements in everyday life, increase of target audience and drop in transaction costs are expected to reduce unemployment rates. For example, Klonner and Nolen (2010) determined in their South African study that employment tends to increase substantially when a locality receives wireless network coverage. In another study, Batzillis et al. (2010) found that wireless coverage is linked to increased female labor participation in Malawi.

This multiple effects of mobile telephony on the economy appear to be characterised by a return to scale, whereby increased penetration tends to enhance the economic impact. According to the “return to scale” effect, the impact of wireless telecommunications on economic output is maximized once the infrastructure reaches a critical mass point, generally associated with levels of penetration of developed countries. As a result, we initially observe increasing returns to growth (see Waverman, Meschi and Fuss, 2005; Shiu and Lam, 2008; Kathuria, Uppal and Mamta, 2009; Andrianaivo and Kpodra, 2011). This effect was also validated by Gruber and Koutroumpis (2011) for a global sample for a period of 18 years (see Figure 1).

![Figure 1: Wireless Telephony contribution to growth versus wireless penetration, Source: Gruber and Koutroumpis (2011)](image-url)
As figure 1 indicates, the magnitude of the contribution of mobile telephony to GDP growth increases with wireless penetration, although effects tend to subside beyond penetration levels of 60%.

2.2 The impact of Broadband on the Economy, Jobs and Welfare

Broadband contributes to economic growth initially by producing a series of effects similar to those generated by infrastructure deployment. Beyond the benefits for GDP growth, it also has significant economic impact on consumer surplus. Some of these effects—such as the impact of investment on infrastructure—have been estimated quantitatively through input-output analyses (Katz et al., 2009a; Katz et al, 2010a). Others, such as the impact on productivity growth and the elasticity of supply, as well as the multipliers of household income, require econometric models and have only recently attracted the attention of policy makers and researchers in the field.

Research in developed countries has begun to generate evidence of causality between broadband and growth, as well as the microeconomic effects it can have on business productivity. Using data from OECD countries, two studies have evaluated the impact of broadband on GDP growth. The first analysed this impact in 25 OECD countries between 1996 and 2007 (Czernich et al., 2009). The authors determined that the adoption of broadband was statistically significant in regard to the rise in per capita GDP, with a ratio of 1.9% to 2.5%. Koutroumpis (2009) tried to solve the underlying problem of endogeneity between variables by constructing a structural model with simultaneous equations. His analysis focused on 22 OECD countries over the period 2002-2007. Again, the results indicated that there is a statistically significant relationship, with a 1% increase in broadband penetration leading to a 0.025% increase in the GDP growth rate. The author also determined that broadband’s contribution to GDP growth increases with its diffusion due to network effects: in countries with low penetration rates (less than 20%), a 1% increase in broadband adoption contributes 0.008% to GDP growth; in countries with an average degree of penetration (between 20% and 30%), the effect is 0.014%; while in countries with high penetration rates (over 30%), the impact on GDP growth rate is 0.023% for every 1% increase in broadband adoption (see Figure 2).
growth was around 0.0255% to GDP growth. This result coincides with previous estimates and, at the same time, validates the existence of an incremental impact of broadband penetration. For the counties with an average penetration of 24.8%, contribution to GDP growth. The estimate was based on a statistical analysis of the impact of broadband adoption (see figure II.2).

On a country level, Katz et al. (2010a) calculated the extent of the contribution that Germany’s national broadband plan could have on the country’s GDP growth. The estimate was based on a statistical analysis of the impact of broadband on economic growth of German counties (landkreisse) between 2000 and 2006. The authors found that a 1% increase in broadband penetration contributes 0.0255% to GDP growth. This result coincides with previous estimates and, at the same time, validates the existence of an incremental impact of broadband penetration. For the countries with an average penetration of 24.8%, contribution to GDP growth was around 0.0238%, while, for those with an average penetration of 31%, broadband contributed 0.0256% to GDP (see table 1).

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Study</th>
<th>Data</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD</td>
<td>Czernich et al. (2009)</td>
<td>25 OECD countries, 1996-2007</td>
<td>Broadband adoption elevated per capita GDP by between 1.9% and 2.5%</td>
</tr>
<tr>
<td></td>
<td>Koutroumpis (2009)</td>
<td>22 OECD countries, 2002-2007</td>
<td>A 10% increase in broadband penetration produced a 0.25% increase in GDP growth</td>
</tr>
<tr>
<td>Germany</td>
<td>Katz et al. (2010a)</td>
<td>424 counties in Germany, 2000-2006</td>
<td>A 10% increase in broadband penetration produced a 0.255% increase in GDP growth</td>
</tr>
<tr>
<td>Developed countries</td>
<td>Qiang et al. (2009)</td>
<td>Developed counties from a sampling of 120 countries, 1980-2002</td>
<td>A 10% increase in broadband penetration produced a 1.21% increase in GDP growth</td>
</tr>
<tr>
<td>Low- and middle-income countries</td>
<td>Qiang et al. (2009)</td>
<td>Remaining countries (low- and middle-income developing economies) from a sampling of 120 countries, 1980-2002</td>
<td>A 10% increase in broadband penetration contributed 1.38% to economic growth</td>
</tr>
</tbody>
</table>

Table 1: Selected research regarding the impact of broadband on growth
The incremental impact of broadband penetration is increasingly validated by a recent study published by one of these authors (Katz, 2012), where countries with lower broadband penetration tend to exhibit a lesser contribution of broadband to economic growth (see figure 3).

![Figure 3: Broadband contribution to growth versus broadband penetration, Source: Katz (2012)](image)

This “return to scale” in broadband has also been verified in mobile networks (as mentioned above) and wireline telephony (see Roller and Waverman, 2001).

Beyond the impact on economic growth, researchers have also studied the subsequent effects of network externalities on employment variously categorized as “innovation”, or “network effects”⁴. The study of network externalities resulting from broadband penetration has led to the identification of numerous effects:

- New and innovative applications and services, such as telemedicine, Internet search, e-commerce, online education and social networking⁵.
- New forms of commerce and financial intermediation⁶.
- Mass customization of products⁷.
- Reduction of excess inventories and optimization of supply chains⁸.
- Business revenue growth⁹.
- Growth in service industries¹⁰.

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⁴ See Atkinson et al., 2009.26-jan.-12
⁹ See Varian et al., 2002; Gillett et al., 2006.
Most of the research regarding the impact of broadband externalities on employment has been conducted using US data, although we have begun to develop studies for emerging countries (see table 2).

Among the econometric studies of employment impact, are Gillett et al. (2006), Crandall et al. (2007), Shideler et al. (2007), Katz (2012) and Thompson et al. (2008) (see table 2).

<table>
<thead>
<tr>
<th>Study</th>
<th>Region/Country</th>
<th>Impact on job creation for each 1% increase in rate of growth of broadband penetration</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Employment</td>
<td>Unemployment</td>
<td></td>
</tr>
<tr>
<td>Katz et al. (2010a)</td>
<td>High developed Counties in Germany</td>
<td>0.0061</td>
<td>• Statistically significant level at 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 214 observations</td>
</tr>
<tr>
<td>Katz et al. (2010c)</td>
<td>Suburban Counties in Kentucky</td>
<td>-0.371</td>
<td>• Statistically significant at 1% level</td>
</tr>
<tr>
<td>Shideler et al. (2007)</td>
<td>Kentucky, USA</td>
<td>0.14-5.32</td>
<td>• Statistically significant level at 1% (total employment)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 114 observations (total). Range varies according the industry analysed (from 20 to 120)</td>
</tr>
<tr>
<td>Katz (2011)</td>
<td>Brazil</td>
<td>-0.0449</td>
<td>• Statistically significant coefficient (t-statistic = 1.73)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 27 observations</td>
</tr>
<tr>
<td></td>
<td>Chile</td>
<td>0.181</td>
<td>• Statistically significant coefficient (t-statistic = 3.85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 324 observations</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>0.02825</td>
<td>• Statistically significant coefficient (t-statistic = 1.86)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 19 observations</td>
</tr>
<tr>
<td></td>
<td>Saudi Arabia</td>
<td>-0.2434</td>
<td>• Statistically significant Coefficient (t-statistic = -8.29)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 13 observations</td>
</tr>
<tr>
<td></td>
<td>Indonesia</td>
<td>-8.6163</td>
<td>• Statistically significant coefficient (t-statistic = -2.58)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 99 observations</td>
</tr>
<tr>
<td></td>
<td>Dominican Republic</td>
<td>-0.2952</td>
<td>• Statistically significant coefficient (t-statistic = -2.22)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 32 observations</td>
</tr>
</tbody>
</table>

Table 2: Country level studies on broadband and their impact on employment

Again, the impact of broadband on employment creation appears to be positive. However, as the data indicates, the impact on employment growth varies widely, from 0.2 per cent to 5.32 per cent for every increase in 1 per cent of penetration. There are several explanations for this variance. As Crandall indicated, the overestimation of employment creation in his study is due to employment and migratory trends, which existed at the time and biased the sample data. In the case of Gillett et al. (2006), researchers should be careful about analysing local effects because zip codes are small enough areas that cross-zip code commuting might throw off estimates on the effect of broadband. For example, increased wages from broadband adoption in one zip code would probably raise rent levels in neighbouring zip codes prompting some

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10 See Crandall et al. (2007).
migration effects. Finally, the wide range of effects in the case of Shideler et al. (2007) is explained by the divergent effects among industry sectors.

As in the case of the relationship between broadband and GDP growth, the contribution of broadband to employment is also conditioned by a number of special effects. Studies have particularly focused on two specific questions:

- Does the impact on employment differ according to industry sector?
- Is there a decreasing return in employment generation linked to broadband penetration?

As with GDP, the spillover employment effects of broadband are not uniform across sectors. The job creation impact of broadband tends to be concentrated in service industries, (e.g., financial services, education, health care, etc.) although some researchers also identified a positive effect in the case of manufacturing (Crandall et al, 2007). Other studies (Shideler et al, 2007) found that, for the state of Kentucky, county employment was positively related to broadband adoption in certain industrial sectors. The only sector where a negative relationship was found with the deployment of broadband (0.34% – 39.68%) was the accommodations and food services industry. This may result from a particularly strong capital/labor substitution process taking place, whereby productivity gains from broadband adoption yields reduced employment. Similarly, Thompson and Garbacz (2008) conclude that, for certain industries, “there may be a substitution effect between broadband and employment”\textsuperscript{11}. It should therefore be considered that the productivity impact of broadband can cause capital-labor substitution and may result in a net reduction in employment.

This particular effect has been analysed by Katz et al. (2011a) in the case of rural economies of the United States. In particular, it was found that, within rural counties, broadband penetration contributes to job creation in financial services, wholesale trade, and health sectors. This is the result of enterprise relocation enabled by broadband, which benefits primarily urban communities in the periphery of metropolitan areas. In fact, research is starting to pinpoint different employment effects by industry sector. Broadband may simultaneously cause labour creation triggered by innovation in services and a productivity effect in labour-intensive sectors. Nevertheless, we still lack a robust explanation of the precise effects by sector and the specific drivers in each case. However, given that the sectorial composition varies by regional economies, the deployment of broadband should not have a uniform impact across a national territory.

Finally, some researchers have found a decreasing impact of broadband on employment as a result of broadband saturation. While Gillett et al. (2006) observed that the magnitude of impact of broadband on employment increases over time, they also found that the positive impact of broadband on employment tends to diminish as penetration increases. This finding may support the existence of a saturation effect.

\textsuperscript{11} This effect was also mentioned by Gillett et al. (2006).
Coincidentally, Shideler et al. (2007) also found a negative statistically significant relationship between broadband saturation and employment generation. This would indicate that at a certain point of broadband deployment, the capability of the technology to have a positive contribution to job creation starts to diminish.

In sum, a review of the research on the economic impact of broadband indicates multiple effects. First and foremost, the evidence is fairly conclusive about the contribution of broadband to GDP growth. While the amount of this contribution varies, the discrepancies can be related to different datasets as well as model specifications. In addition, the research has been successful in identifying the existence of a critical mass, indicating the existence of increasing economic returns of broadband penetration.

Secondly, broadband does contribute to employment growth following spillover impacts on the rest of the economy. While the deployment programs are, as expected concentrated in the construction and telecommunications sectors, the impact of externalities are greater in sectors with high transaction costs (financial services, education, and health care).

We will now turn to reviewing the main features of the Senegalese economy in order to measure the impact of telecommunications.

3. The Senegalese Economy

Senegal is a sub-Saharan country with a large part of rural population (60%), with limited natural resources located on the westernmost point of Africa. Its key export industries are commercial fishing, phosphate mining, and fertilizer production. Iron ore and oil exploration projects also contribute to the gross domestic product as well as tourism, services and peanuts’ production. Its economy depends on rainfall variations, which combined with a lack of strong monetary policy make Senegal vulnerable to changes in world commodity prices. Senegal also relies heavily on donor assistance, representing almost a quarter of its government spending in 2007\textsuperscript{12}.

The country is a member of the West African Economic and Monetary Union (WAEMU), with an overarching objective of stabilizing the monetary policy of the region. High unemployment impedes this process leading a significant proportion of young inhabitants to immigrate to Europe. Under the IMF's Highly Indebted Poor Countries (HIPC) debt relief program, the Multilateral Debt Relief Initiative (MDRI) and other bilateral debt relief initiatives, Senegal eradicated significant proportion of its gross debt and allocated its payment to infrastructure and poverty aid. The latest Debt Sustainability Analysis (DSA) by the IMF\textsuperscript{13} has resulted in a debt-restructuring plan to help the sustainability of the energy sector with the issuance of a new 10-year

\textsuperscript{12} Source: CIA Fact book, US State Department \textsuperscript{13} May 20, 2011
$540 million Eurobond in exchange for the previous (2009) 5-year coupon. The revised macroeconomic forecast under the new DSA is presented in Table 3.

<table>
<thead>
<tr>
<th>Evolution of selected macroeconomic indicators</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real GDP Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous DSA</td>
<td>2.2</td>
<td>4.0</td>
<td>4.4</td>
<td>4.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Current DSA</td>
<td>2.2</td>
<td>4.2</td>
<td>4.5</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Primary Fiscal Deficit (percent of GDP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous DSA</td>
<td>4.1</td>
<td>3.9</td>
<td>4.7</td>
<td>3.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Current DSA</td>
<td>4.1</td>
<td>4.3</td>
<td>5.7</td>
<td>4.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Overall Fiscal Deficit (percent of GDP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous DSA</td>
<td>4.9</td>
<td>4.8</td>
<td>5.8</td>
<td>5.3</td>
<td>3.9</td>
</tr>
<tr>
<td>Current DSA</td>
<td>4.8</td>
<td>5.2</td>
<td>6.9</td>
<td>5.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Current Account Deficit (percent of GDP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous DSA</td>
<td>7.7</td>
<td>8.2</td>
<td>9.0</td>
<td>9.5</td>
<td>9.1</td>
</tr>
<tr>
<td>Current DSA</td>
<td>6.7</td>
<td>5.9</td>
<td>8.4</td>
<td>8.0</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 3: IMF Debt Sustainability Analysis, May 2011 (Source: IMF)

Intra-sector economic contribution varies substantially in Senegal with the fishing sector retaining the leading export position. Almost a quarter of Senegal’s export earnings come from industrial fisheries and about 15% of the population works in this field. The lack of competitiveness and higher costs hinder national exports in favour of more efficient European and Asian counterparts. Poachers often exploit Senegal’s territorial waters further reducing the returns from commercial fisheries. Tourism is the second major sector contributing 5-7% of GDP annually. Senegal has three hundred tourist-class hotels, and the sector employs about 0.9% population. Agriculture employs three quarters of the labour force, mainly on groundnut population (10% of the labour force). Phosphate mining has a significant export value (15% of total export value) and employs about 0.3% population.

The global recession in 2009 and the Senegalese food and energy crisis of 2008 have hit the economy hard and slowed its development. Recovery began in 2010 after a combination of domestic structural reforms and the improved results of the global economy. Gross domestic product (GDP) grew from 2.2% in 2009 to 4.2% in 2010, and is projected to reach 4.5% in 2011 and 5.0% in 2012.

The Senegalese economy suffered the repercussions of the global recession more than its West African neighbours in the region of Western Africa during 2008 and 2009 but overall it remained aligned with the average growth figures and forecasts across the continent. In particular, the real GDP growth of the Western Africa region has remained fairly stable (around 6% year-on-year) since 2005 after a sharp drop in 2003 (see figure 4).
The population continued to grow at an annual rate of 2.66% in 2010 almost identical to the average growth rate of the past decade (2.67% during 2000-2010). Net emigration in 2010 fell slightly, reaching 1.07% of total population resulting in an annual implied labour force increase of 1.49%. Gross Domestic Product per capita (GDPC) growth slowed in 2006 and 2009 reaching US$ 560.6 (in constant US$ 2,000 figures) in 2010. The start of the recovery in the Senegalese economy is also depicted by the changes in inflation. After a sharp rise during 2005-2008, inflation turned negative reaching -0.98% in 2009 and 1.37% in 2010. In 2011 inflation is forecast at 3% mainly as a result of higher energy prices (see figure 5).
Total imports of goods and services have steadily grown after 2001 reaching a peak of 53.8% of GDP in 2008 but experienced a sudden drop in 2009 and 2010 declining to 44% of GDP. Exports have followed a downward trend during the last decade further expanding the external balance of goods and services at a maximum of 26.5% in 2008 (see figure 6).

Foreign Direct Investment dropped from 3.01% of GDP in 2008 to 1.62% in 2009 and reached 1.83% in 2010. The rate of investment measured by the Gross Fixed Capital Formation (GFCF) was positive: 27.97% of GDP in 2009 and 28.93% in 2010. It is forecast that Senegal’s external position will gradually improve during 2012 (8.0%) and 2013 (7.5%) after a steep increase at 8.4% in 2011\(^{14}\). The overall budget deficit, including grants, increased by 0.3 percentage points, from 4.9% of GDP in 2009 to 5.2% in 2010. It is estimated to peak at 6.9% in 2011 and gradually drop at 5.6% in 2012 and 4.6% 2013. Temporary high levels of energy-related expenditures will result in larger fiscal deficits over the medium term. Resolving the energy sector inefficiencies is expected to eliminate a serious impediment to growth in Senegal, leading to upward revisions of GDP growth.

In light of this macro-economic and sector analysis, telecommunications could play a significant role in contributing to the development of the Senegalese economy. Based on the economic impact analysis highlighted in chapter 2, efficient and affordable telecommunications could improve the performance of fishing, as the leading export industry. Similarly, broadband could enhance the efficiency of the tourism sector, while mobile telecommunications and broadband could foster social and financial inclusion of wide portions of marginalized population.

\(^{14}\) The 2011 IMF Debt sustainability Analysis (DSA)
4. The Telecommunications industry in Senegal

4.1 Telecommunications demand

The Telecommunications sector has grown rapidly during the last 15 years in Senegal primarily bearing to the adoption of mobile telephony (see figure 7).

![Figure 7: Mobile, Fixed-line, Broadband and 3G subscribers in Senegal, Source: ARTP Senegal (2011)](image)

However, in addition to the dramatic increase in wireless subscribership, fixed lines have also increased since 2008. Fixed lines have experienced a very slow rate of adoption before 2007 reaching 286,000 lines. Significant substitution effects took place after the quick adoption of mobile services resulting in 21% drop in fixed line services during 2007-2009. This three-year drop in fixed line subscribers lasted until the second quarter of 2009. A steep rise in the demand of ADSL lines after 2009 has turned this trend, reaching an all time high in 2011 (358,000 lines).

Fixed line networks have been thin on the ground for a long time in Senegal, with a total deployed lines stagnating between 2006 (282,088) and 2010 (282,722) (Source: Sonatel). The rapid take off of mobile services was achieved due to the technology’s capacity to tackle the chronic problems that kept fixed networks on the ground: high connection fees and recurrent monthly payments that are largely unsuitable for the vast majority of sub-Saharan African subscribers. In particular, the launch of prepaid mobile schemes, with relatively low connection fees and ‘a la carte’ micro payments led this communications’ revolution.

15 Less than the local currency equivalent of S2
16 A simple ‘top up’ starts at the local currency equivalent of $0.25
This phenomenon of simultaneous growth of both technologies indicates an industry context of a market searching for any possibility to meet its needs through either technology. While the growth rate in mobile telephony is dramatically higher than wireless, the Senegalese market exhibits less of a technology substitution dynamic as the one that can be seen in other emerging countries\textsuperscript{17}.

Mobile subscribers have exceeded 9.3 million in 2011, reaching 74.94%, thereby representing the most popular telecommunications platform in Senegal. The growth rate and the net additions per quarter have continued to rise throughout 2010 and 2011. Senegal has remained above the West Africa average mobile penetration (54.3% in 2010) and ranks 7\textsuperscript{th} behind Gambia, Cape Verde, Mauritania, Benin, Cote d’Ivoire and Ghana (see figure 8).

\begin{figure}[h!]
\centering
\includegraphics[width=\textwidth]{figure8.png}
\caption{Senegal belongs to the leading cluster for mobile penetration in West Africa, Source: ITU (2011)}
\end{figure}

The vast majority (99.4\%) of Senegalese mobile subscribers use prepaid services and only 60,000 have contracts. In terms of technology, 99.4\% of the subscribers use second-generation services (GSM) with 54,000 lines connected to 3G networks.

\textsuperscript{17} See the example of Latin American countries
Since the beginning of 2010, broadband, both through wireline and wireless technologies, has also been increasing at a growth rate similar to that of mobile telephony. However, the broadband market is still at its infancy with a combined (fixed and mobile) subscriber penetration now at 1.50%. Occasional internet users in Senegal exceed 923,000 but this is not reflected in the subscription metrics. The main reason is that Senegal is home to more than 4,000 telecenters that allow communal access to basic services like telephony, internet browsing, fax, printing etc.

The main forms of fixed line broadband have been the simple PSTN (dial-up) services and now ADSL. Broadband penetration now accounts for 0.75% having experienced almost twice the demand and net additions per quarter after 2010. Wireline penetration is 0.3% penetration (Q2 2011) and continue to decrease. The most significant boost in the Senegalese broadband market has been the deployment and launch of 3G networks that now account for almost one third of broadband connections. Their adoption is so dynamic, that it is forecast in Q4 2012 they will represent 81% of the broadband market.

4.2 Telecommunications supply

From an industry structure, the mobile market was still a monopoly of the local incumbent – Sonatel, now Orange Senegal - until 1999 when a second operator – Tigo – entered. In 2009, Expresso, the third operator started to provide services in the Senegalese market. The local regulator, Agence de Régulation des Télécommunications et des Postes (ARTP), has yet to apply number portability

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18 Local operators have indicated that frequent users of the Internet through telecenters exceed the actual subscribers of ADSL networks by a factor of 10.
mandates. The market is still primarily controlled by Sonatel (60.41% in 2010) while Tigo has 27.96% of the customer base, and Expresso the remaining 11.63%.

<table>
<thead>
<tr>
<th></th>
<th>Local</th>
<th>Broadband</th>
<th>Wireless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonatel</td>
<td>100%</td>
<td>97.41%</td>
<td>60.41%</td>
</tr>
<tr>
<td>Tigo Senegal</td>
<td></td>
<td></td>
<td>27.96%</td>
</tr>
<tr>
<td>Others</td>
<td>2.59%</td>
<td></td>
<td>11.63%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4: Subscriber market shares across telecommunications platforms in Senegal (2010), Source: France Telecom

Total Service revenues have seen a seven-fold increase since 2001, now well above 1.4 billion current USD. The trend clearly relates to the rise in mobile adoption and usage as well as the subsequent increase in competition and drop in tariffs. Revenues have also been hit by the macroeconomic conditions and food and energy crises in 2008 and 2009 breaking an increasing trend of more than 10 years and leading to a net drop in 2009. Results increased slightly in 2010 but have yet to regain the previous momentum (see figure 10).

As a result, the elasticity of telecommunications demand with respect to the growth of the economy is still behind that experienced between 2001 and 2008 (see figure 11).
This has to be considered in the context of the dramatic growth of mobile telephony. In fact, the stabilization of revenue growth is primarily due to the decline in mobile ARPU resulting from increased competition.

5 The economic impact of telecommunications in Senegal

The impact of telecommunications on the Senegalese economy needs to be assessed first in terms of the sector’s direct impact, resulting from its importance in the GDP, as well as the employment being generated by its operators and their local suppliers. On the other hand, the sector also contributes to the economy by means of taxes, such as corporate levies, value-added tax, and other fees. Finally, as a general purpose technology, telecommunications also has an impact resulting from the positive externalities as was reviewed in chapter 2. This chapter will assess the direct and indirect contribution that telecommunications has had so far to economic development in Senegal.
5.1. Direct economic contribution

The total revenues of the Senegalese telecommunications industry represented 1.4 billion USD (10.8% of the national GDP) in 2010. This ratio has been consistently growing since 2002 indicating the increasing importance of the sector (see figure 13).

![Figure 13. Percentage of GDP, Sources: IMF; World Bank (2011)](image)

Furthermore, the value-added of the telecommunications and postal services sectors has reached 850 million USD while its contribution to GDP growth was 104 million USD (8.5%), the highest across industrial sectors\(^\text{19,20}\). When comparing it against other sectors, the direct contribution to GDP growth of the telecommunications and postal services sectors is higher than energy, construction, and finance (approximately 26 million USD each sector).

Furthermore, if one were to add the domestic suppliers of goods and services to the telecommunications industry, its total contribution would be even higher. As an indication, the consumption of domestic and imported intermediate products of the telecommunications and postal services industries represents 36% of its total output.

In parallel to its direct economic contribution, the telecommunications industry has an important impact in the creation of direct jobs (i.e. telecommunications employment). The total number of direct jobs in telecommunications reached 3,000, while the indirect employment reached 55,000. The total direct and indirect employment figure represents 1.11% of the total employment in Senegal, and 10.6% of the service sector\(^\text{21}\).

\(^{19}\) When considering it with transportation (Source: National Accounts)

\(^{20}\) GDP of Senegal in 2010 was $12,954 m (current)

\(^{21}\) Total population employment reached 5,194,107 in 2010; according to the Youth Employment Network study on Ghana and Senegal, 10.5% of the labor force is employed in the service sector
Finally, the Senegalese telecommunications sector contributes 12.6% to the public treasury in terms of taxes being paid. For example, Sonatel, the incumbent operator, contributes to 10.4% of the total fiscal revenues of the country.\(^{22}\)

5.2. Indirect economic contribution

As shown in the literature reviewed above, beyond the direct economic contribution, telecommunications can have a positive contribution to economic growth. This section assesses the positive externalities of telecommunications for the case of Senegal. As anticipated in the introduction, given the different penetration rates exhibited by mobile telephony and broadband, the analysis of economic impact of both technologies will be conducted through a structural econometric model.

5.2.1. Data Availability

Regional and country-level statistical studies of ICT impact in emerging economies usually suffer from the lack of microdata as the institutions and technical committees do not always collect information in a relatively frequent and consistent manner. This situation introduces a degree of complexity in the data mining phase. This study relied on two points of reference for telecommunications data: the local regulator - Autorité de Régulation des Télécommunications et des Postes (ARTP) - and the local mobile and fixed line operators (Sonatel, Tigo and Expresso).

Adoption metrics (mobile, fixed line, ADSL) have been fairly consistent since the fourth quarter of 2003 up until 2010. Telecommunications’ costs are provided by the operators and in the case of mobiles are disaggregated in pre- and post-paid ARPUs. Other macroeconomic metrics (GDP, fixed capital formation, education, labor force etc) are available from the corresponding sector ministries. Market performance metrics (capex, revenues etc) are also available from local operators.

5.2.2 Mobile telephony economic impact

In this study a structural econometric model, initially developed by Roller and Waverman (2001) for fixed line telephony and later adapted by Koutroumpis (2009) for broadband and Gruber and Koutroumpis (2011) for wireless, has been used. In particular, the model consists of four equations: an aggregate production function modelling the operation of the economy and subsequently three demand, supply and output functions. The last three functions model the mobile market operation and, controlling for the reverse effects, the actual impact of the infrastructures is estimated. In the production function, GDP is linked to the fixed stock of capital, excluding ICT infrastructure and labour and the mobile infrastructure proxied by mobile penetration.

The demand function links mobile penetration to the average consumption propensity of individuals proxied by GDP per capita, the cost of a basic mobile service (price of a 3 minute call and a text message) and the competition in the mobile market.

The supply function links the aggregate mobile revenue to mobile price levels, the industry concentration index of the mobile market (HHI) and GDP per capita. These parameters affect potential and existing operators as well as the dynamics of the supply side of the market.

The infrastructure equation links annual change in mobile penetration to mobile revenues, used as a proxy of the capital invested in a country during one year.

The econometric specification of the model is as follows:

**Aggregate Production function:**

\[ GDP_{it} = a_1K_{it} + a_2L_{it} + a_3Mob\_Pen_{it} + \epsilon_{1it} \]  

(1)

**Demand function:**

\[ Mob\_Pen_{it} = b_1MobPr_{it} + b_2GDPC_{it} + b_3HHI_{it} + \epsilon_{2it} \]  

(2)

**Supply function:**

\[ Mob\_Rev_{it} = c_1MobPr_{it} + c_2GDPC_{it} + c_3HHI_{it} + \epsilon_{3it} \]  

(3)

**Output function:**

\[ \Delta Mob\_Pen_{it} = d_1Mob\_Rev_{it} + \epsilon_{4it} \]  

(4)

Based on these models, mobile telephony has been found to significantly affect the Senegalese economy during the last 7 years (2003-2010). The annualized average contribution to the Gross Domestic Product has been estimated to be equal to 0.044% growth of GDP for every 1% increase of Mobile penetration (see table 5).

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23 This assumes a stable and constant link between income and investment, which in some cases might not be the case. Unfortunately, fixed gross capital formation for telecoms, which would be the more appropriate variable, was not available.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Mobile Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth (GDP&lt;sub&gt;t&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>Labour force (L&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.416***</td>
</tr>
<tr>
<td>Fixed Capital Stock (K&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.615***</td>
</tr>
<tr>
<td>Mob Penetration (Mob_Pen&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.044*</td>
</tr>
<tr>
<td>Constant</td>
<td>-</td>
</tr>
<tr>
<td><strong>Demand (Mob_Pen&lt;sub&gt;t&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>GDPC (GDPC&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.165</td>
</tr>
<tr>
<td>Mob. Price (MobPr&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>-5.238***</td>
</tr>
<tr>
<td>Market Conc (HHI&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>-3.590***</td>
</tr>
<tr>
<td>Constant</td>
<td>10.588***</td>
</tr>
<tr>
<td><strong>Supply (Mob_Rev&lt;sub&gt;t&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>Mob Price (MobPr&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>-3.122***</td>
</tr>
<tr>
<td>GDPC (GDPC&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.929***</td>
</tr>
<tr>
<td>Market Conc (HHI&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.123</td>
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<tr>
<td>Constant</td>
<td>-3.360***</td>
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<tr>
<td><strong>Output (∆Mob_Pen&lt;sub&gt;t&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>Mob Revenue (Mob_Rev&lt;sub&gt;t&lt;/sub&gt;)</td>
<td>0.867***</td>
</tr>
<tr>
<td>Constant</td>
<td>7.150***</td>
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<td>Year Effects</td>
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<tr>
<td>Quarter Effects</td>
<td>YES</td>
</tr>
</tbody>
</table>

R²:  (1)  
Growth: 0.99  
Demand: 0.98  
Supply: 0.98  
Output: 0.30

Table 5. Results of Mobile Telephony Model

This figure is of high importance, given the small fraction of the population that initially adopted the technology. In practice, only a tenth of the population used mobile phones in 2004 and this might include multiple SIM-card ownership. The interpretation of this outcome requires a better understanding of the location specific parameters. In terms of actual growth contribution of the technology, the Compound Annual Growth Rate (CAGR) attributed to mobile infrastructure derives from formula (5):

\[
CAGR = \left[ \left( \frac{Pen_{2010}}{Pen_{2004}} \right) \frac{Pen_{2008}}{100} \right] + \alpha + 1 \right]^{1/7} \tag{5}
\]

24 It is commonly found in similar studies, that a variable percentage of the users owns more than one subscription. This might lead to an overestimation of actual users and is directly related to the cost barriers of new SIM card acquisition. Stronger regulation of phone ownership can radically reduce this phenomenon.

25 We follow the analysis in Koutroumpis (2009).
The CAGR for Senegal for the period 2004-2011, i.e. the annual contribution on GDP form mobile phones is approximately 0.55% of GDP. Given that the economy grew – on average – at 4.1% during this period, this figure suggests that mobiles alone were responsible for 13.6% of all economic growth in Senegal.

Subscribers in Senegal use mobile phones predominantly for voice services. The percent of voice revenue in 2006 was 95% of the industry, although it dropped to 85% in 2010 – primarily due to the large margins over data services. The contribution of voice services to the local economy has acted on two levels: wireless subscribers have quickly surpassed fixed lines and provided the country with a rapid rollout of simpler communications services. This fixed substitution effect is one reason why the returns in Senegal might reflect a catch-up effect too; until 2006, only half of Senegal was covered by a basic fixed access network.

The second level of contribution is mobility. Coordination of everyday activities – business or personal – is much more productive with the added value of mobility. Urban and rural population can use the same platform for an immense diversity of needs only restricted by adequate network coverage.

In terms of data services, they are now starting to become an important part of the subscribers’ basket. Their impact could be found after a period of incubation of eGovernement, eHealth, eBanking and other more advanced services (see figure 14).

![Figure 14: Fixed and mobile coverage, Source: Sonatel](image)

Looking again at the results, Senegal firmly fits the exponential growth impact curve of Gruber and Koutroumpis (2011). With a median mobile penetration of approximately 35% in the sample period, the country has a coefficient of 0.044 implying a 0.044% increase in GDP for every 1% increase in mobile penetration. This
estimate is only 3% lower than the estimate of the exponential model\textsuperscript{26} (see figure 15).

Based on the prior model, we have explored the expected impact of the sector according to industry forecasts. It is estimated that mobile penetration will reach 115% by the end of 2016 suggesting the formation of a saturated market – given the usage of multiple cards per subscriber. This estimate will effectively shift the median mobile penetration for the period of study (2004-2016) to 61.4% and suggests an annual impact from each 1% increment of mobile penetration to contribute slightly more than 0.05% on GDP (see figure 16).

\begin{align*}
\text{Estimated value: } & (0.0074 \times \ln(0.35)) + 0.0533 = 0.0455, \\
\text{Actual estimate: } & 0.44
\end{align*}

\textsuperscript{26} Estimated value: (0.0074 * ln(0.35)) + 0.0533 = 0.0455, Actual estimate: 0.44
This in turn implies that the contribution of mobile telephony on GDP, until 2016 is expected to be 0.62% annually, driven by the higher impact of mobile contribution and the gradually saturating market. Given the IMF projection for the period (2009-2016), GDP is expected to grow at a rate of 4.6% thus implying that mobile networks account for 13.7% of all growth in the country. Market saturation suggests that the effect of mobile adoption growth stagnates during 2015 and the growth effects will be preserved and transferred to data and broadband platforms.

Besides, the structural model provides estimates for other important parameters of the economy. The capital contribution is approximately 60% of total (0.615) and the labour 40% (0.41) which is an expected outcome of capital and labor contributions.

---

27 We estimate the CAGR based on the period 2009-2016 using formula (5).
In terms of demand of mobile service, prices and competition are the key enablers for adoption of the technology. Income variation across the sample period does not seem to have significantly affected the growth of mobile penetration. While this is not usual in such studies, it is not necessarily unexpected. Senegal had strong demographic dynamics and a relatively unstable economic performance during the sample period.

Supply dynamics suggest that income levels affect the revenues and investments of operators. Prices seem to negatively affect telecom firms’ economic performance, a rather expected finding. However, competition is not significantly affecting results, primarily due to the strong growth of mobile subscribers in the period of study.

Finally revenues are found to have a significant impact on the performance of the industry, implying a reinvestment of the output to the productive basis of the economy\textsuperscript{28}. This is an additional angle supporting the increasing returns to scale of ICT infrastructures.

### 5.2.3 Broadband economic impact

For the analysis of the impact of broadband on the Senegalese economy a model similar to the mobile telephony structural model was utilized. The model also consists of four equations: an aggregate production function modelling the operation of the economy and subsequently three demand, supply and output functions. The latter functions model the broadband market operation and estimates the economic impact of broadband, while controlling for the reverse effects.

It is worth emphasizing that the Senegalese broadband market poses some important differences compared to other country-level studies. Part of the population frequently accesses the Internet through telecenters but this is not taken into account in the broadband market model. The reason for this is two-fold. First the contribution of shared ownership to the broadband telecoms market is marginal if it actually exists. Second, shared ownership of any telecommunications’ connection is possible in many cases but rarely has the impact of the individualized use from the local business or home. The same argument could lead us to share other important utilities like water, electricity or the road networks of other users. However, this is not compared to the dedicated service for each home/business or subscriber in general.

Going back to the model, GDP is linked in the production function to the fixed stock of capital excluding ICT infrastructure, labour and the broadband infrastructure proxied by broadband penetration.

\textsuperscript{28} This is particularly relevant for markets undergoing high growth, while it not be the case with saturated markets.
The demand function links broadband penetration to the average consumption propensity of individuals proxied by GDP per capita, the cost of a basic ADSL service (price of a monthly subscription), the percent of individuals that fulfil secondary education and the percent of population residing in densely populated urban areas. Education and urbanization are both critical for ADSL networks as these demand significant ICT literacy skills and coverage is usually higher in urban demographic segments.

The supply function links the aggregate ADSL revenue to the relevant price levels and the GDP per capita. Due to the quasi-monopolistic nature of the market, there is limited competition.

The infrastructure equation links annual change in ADSL penetration to the market revenues, used as a proxy of the capital invested in a country during one year.

The econometric specification of the of the model is as follows:

**Aggregate Production function:**

\[ GDP_{it} = a_1 K_{it} + a_2 L_{it} + a_3 BB\_Pen_{it} + \varepsilon_{1it} \]  \hspace{1cm} (6)

**Demand function:**

\[ BB\_Pen_{it} = b_1 BBPr_{it} + b_2 GDPC_{it} + b_3 Edu_{it} + b_4 Urb_{it} + \varepsilon_{2it} \]  \hspace{1cm} (7)

**Supply function:**

\[ BB\_Rev_{it} = c_1 BBPr_{it} + c_2 GDPC_{it} + \varepsilon_{3it} \]  \hspace{1cm} (8)

**Output function:**

\[ \Delta BB\_Pen_{it} = d_1 BB\_Rev_{it} + \varepsilon_{4it} \]  \hspace{1cm} (9)

According to the model, there is still no significant effect from the adoption of broadband in Senegal for the period 2003-2010 (see table 6).
<table>
<thead>
<tr>
<th>Variables</th>
<th>Broadband Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth (GDPC&lt;sub&gt;i&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>Labour force (L&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.402***</td>
</tr>
<tr>
<td>Fixed Capital Stock (K&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.552***</td>
</tr>
<tr>
<td>Broadband Penetration (BB_Pen&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>-0.003</td>
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<td>Constant</td>
<td>-</td>
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<tr>
<td><strong>Demand (BB_Pen&lt;sub&gt;i&lt;/sub&gt;)</strong></td>
<td></td>
</tr>
<tr>
<td>GDPC (GDPC&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.832**</td>
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</tr>
<tr>
<td>Education (Edu&lt;sub&gt;i&lt;/sub&gt;)</td>
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<td>Urbanization (URB&lt;sub&gt;i&lt;/sub&gt;)</td>
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<table>
<thead>
<tr>
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<th>R&lt;sup&gt;2&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>Growth</td>
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<tr>
<td>Supply</td>
<td>0.35</td>
</tr>
<tr>
<td>Output</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Table 6. Results of Broadband Impact Model

This result is not inconsistent with the findings yielded by other studies such as the one recently completed for the country of Colombia (Katz et al., 2011d), where broadband penetration of 4.83% yields an economic contribution of 0.003% to GDP growth for every 1% increase in penetration.

This is primarily related to the very low network coverage, the monopolization of the market and the subsequent higher prices and the limited consumer interest due to minimal e-government and other applications. On this last point, the recently completed study for Colombia indicates that the introduction of e-government applications has a positive impact on broadband penetration: an increase of 1 percentage point in e-Government users results in .55 percentage points increase in broadband penetration (although causality works in reverse as well).

The future of broadband in Senegal appears quite dynamic into tackling this situation. DSL lines are expected to exceed 200,000 subscribers by 2016. However the real
growth potential comes from the adoption of 3G and EDGE networks in the country. These connections will represent more than a third of all population and could help drive the adoption considerably higher than the current situation suggests. Sonatel reports that its mobile broadband network covers 30% of population and expects to reach 95% by 2016.

![Figure 19: DSL forecast in Senegal, (Source: Informa Telecoms and Media)](image19)

![Figure 20: 3G and EDGE forecast in Senegal, (Source: Wireless Intelligence)](image20)

The structural model depicted in table 6 provides again some interesting estimates for other important parameters of the Senegalese economy. The capital labor contribution is at the expected 60/40 percent contribution level suggesting a first level of validity for the results.
In terms of demand of ADSL service, income and urbanization positively affect the adoption of the technology. Education enters the regression without statistical significance, suggesting that ICT literacy is not highly correlated with secondary education completion. Nonetheless, urbanization is usually a significant parameter for ADSL coverage and demand as there are significant scale economies from dense demographic segments. Prices negatively affect adoption, as expected, at the 1% level.

Supply dynamics suggest that disposable income affects the revenues and investments of operators. Lack of competition makes pricing a rather insignificant parameter of supply, as there is no new entry in the market during the period of study.

Revenues are found to be insignificant in terms of the output of the industry, implying a lack of adequate investment in the market during that period. This result should be analyzed further as the broadband industry has a significant multiplying effect on economic growth that Senegal failed to realize in the recent past.

6 Policy Implications to facilitate telecommunication adoption and welfare

The contribution of digital networks on the improvement of the socio-economic conditions in Senegal can be realized by the applications and services that will be created and used rather than the infrastructure itself. The importance of digital connectivity in the country may affect sectors like education, health and others.

6.1. Education

The Senegalese educational system suffers from several impediments in its practice, predominantly low income, social exclusion, lack of basic amenities, high drop-out rates, adult illiteracy and others. UNESCO reports that over 360,000 children in Senegal are out of compulsory primary education and that on average adult population attended only 2.6 years of schooling.

There has been an abundance of limited-scale pilot projects in sub-Saharan Africa to aid the educational development of remotely located population. The Pan-African Research Agenda on the Pedagogical Integration of ICT’s Observatory represents the most crucial element of this approach. Senegal has 11 participating institutions on this observatory. Additionally Sonatel has agreed to provide rebates in Internet connectivity for schools in order to help the promotion of ICT technologies and improve digital literacy.

ICT can be viewed as the vehicle for improvement in the educational environment, openness of the economy and development of socially excluded population. Apart from the deployment of the underlying infrastructure (3G and broadband) any ICT application for the Senegalese system has to account for the particularities of the
learning process in this unique environment. Recent projects have shown that the mere purchase of high capacity hardware to schools does not suffice and pilots designed for developed countries do not necessarily work in sub-Saharan environments. Monitoring and evaluation of the process is a prerequisite while importing ‘canned’ material from other applications does not work. These projects require training of the teaching staff and extensive planning to avoid lock in from vendors etc.\textsuperscript{29}

The extensive inclusion of ICT in the Senegalese educational system needs careful planning from the government and the operators. This process should allow for some leeway in the application but not the policy imperatives room and maintain a high level of training for the teaching staff.

6.2 Health

After the initial introduction of the Senegalese eGovernment policy in 2001, a national ICT procurement policy for the health sector started to be partially implemented (2006). The country is expected to meet its health related Millennium Development Goals by 2015 through an extensive decentralization of its health care system and facilities. Additionally the government works together with the African Development Bank and UNICEF in order to improve the health care sector.

While medical, nursing and public health professional groups report to have received continued ICT training after graduation the country still lacks a national telmedicine policy. The reasons identified include cultural and organizational barriers coupled with a lack of nationally accepted standards and knowledge of applications according to the World Health Organization\textsuperscript{30}. Health professionals also report a critical shortfall of infrastructure, clinical efficiency and evaluation processes.

MHealth has started to increase with several initiatives taking place in the country. However the high perceived cost of implementation and the competing policy priorities are reported to affect the quick implementation. Senegal and Kenya have funded and adopted the mobile application EpiSurveyor\textsuperscript{31} that replaces the manual public health data collection process. Other applications can significantly contribute to improve life quality and substantially increase life expectancy.

These parameters can have a dramatic effect on the development of the national performance and wellbeing while close collaboration with operators, universities and equipment vendors can help lift the barriers currently faced.

6.3 E-Government

\textsuperscript{29} Comments from Michael Trucano, World Bank ICT in Education
\textsuperscript{30} http://www.who.int/goe/publications/atlas/sen.pdf
\textsuperscript{31} http://www.cio.de/index.cfm?pid=156&pk=884595&p=1
To complement the development of applications in health and education, there is an opportunity to enhance the delivery of government services via ICT. Senegal is seriously lagging in the development of E-Government, as indicated by the E-Government index calculated by the United Nations Public Administration Network\textsuperscript{32}. As indicated above, the development of ICT enabled government applications not only would improve the quality of life of the population; it will also represent an incentive to accelerate the adoption of broadband.

7 Conclusion

The Senegalese market appears to be in a transitional phase in terms of ICT adoption. With mobile telephony having already a significant impact on the economy, the West-African nation has managed to improve its basic communication needs and overcome the serious impediment of low fixed lines adoption. As the next step is upon it, higher connection speeds through 3G or fixed broadband networks will be required. These connections are costly to build and use while the country seems to be in a fairly uncertain macroeconomic situation. As ADSL lines never took off, both due to affordability and coverage, 3G looks like a great candidate to put the country on the global broadband map. Two mobile operators (Sonatel and Expresso) compete in this precious spectrum band helping reduce prices and provide higher quality of service. Given the high risk and cost of this undertaking, operators would welcome regulatory incentives to invest in mobile broadband and allow the development of applications and content in the areas of Education, Media, Health, e-Commerce, e-Government. Given the extensive coverage of existing mobile networks these applications would guarantee a steady growth of mobile data demand and broadband adoption in Senegal especially in rural areas.

In practice, Senegal is a fertile technological greenfield already ripe for an abundance of applications and services that could drastically reduce poverty, increase life quality, sustain growth and promise a much brighter future.

\textsuperscript{32} Senegal scores 0.2241, and is in position 163 out of 183 countries.
Bibliography


